Cited in 8373

PATENT SPECIFICATION

DRAWINGS ATTACHED

965,741

965,741

Date of Application and filing Complete Specification Jan. 15, 1963.

No. 1767/63.

Two Applications made in United States of America (Nos. 176,960, 176,962) on March 2, 1962.

Application made in United States of America (No. 177307) on March 5, 1962.

Complete Specification Published Aug. 6, 1964.

Index at acceptance: —H1 T(1F, 6, 7A2A)

International Classification: —H 02 l

COMPLETE SPECIFICATION

Transformer Core

We, CORE MANUFACTURING COMPANY, a corporation organized under the laws of the State of Missouri, United States of America, of 100 West Ninth Street, Washington, Missouri, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to transformer cores and in particular to laminated cores of closed loop form having butt joints in the individual laminations.

According to one aspect of the invention there is provided a transformer core including a plurality of metal laminations each forming a substantially rectangular closed loop and each having a butt joint in at least one side of the loop, the butt joints of adjacent laminations being arranged in staggered relation along at least part of the length of each of two different limbs of the core formed by sides of adjacent laminations, and at least one innermost and/or outermost lamination having a butt joint in a side of its loop remote from the butt joints in the laminations adjacent thereto.

According to another aspect of the invention there provided a transformer core including a plurality of metal laminations each forming a substantially rectangular closed loop and each having two butt joints one in each of two opposite sides of the loop, the butt joints in adjacent laminations being arranged in staggered relation along at least a part of the length of each of two opposite sides of the core and at least one innermost and/or outermost lamination having a butt joint in a side of its loop remote from the butt joints in the laminations adjacent thereto.

According to a further aspect of the invention there is provided a three phase transformer core comprising three groups of metal laminations each lamination forming a substantially rectangular closed loop and each having a butt joint in at least one side of the loop, the butt joints of adjacent laminations in each group being arranged in staggered relation along at least part of the length of one side of the rectangular loop formed by such group, and the groups being so arranged that the staggered butt joints of at least two of said groups lie in different limbs of the core, and at least one innermost and/or outermost lamination having a butt joint in a side of its loop remote from the butt joints in adjacent laminations.

According to yet another aspect of the invention there is provided a three phase transformer core comprising three groups of metal laminations each lamination forming a closed loop and having two butt joints one in each of two opposite sides of the loop, the butt joints in each said group being arranged in staggered relation along at least part of the length of each of said two opposite sides of the loop of that group and at least one innermost and/or outermost lamination having a butt joint in a side of its loop remote from the butt joints of adjacent laminations.

The various features and advantages of the invention will be apparent from the following description of some exemplary embodiments thereof taken in conjunction with the accompanying drawings.

In the drawings.

Figure 1 is an end elevation view of a reduced scale of a plurality of concentric

[Price 4s. 6d.]

Price 25p

laminations wound in a toroid from which the core of this invention is formed;

Figure 2 is an end elevation view of one embodiment of the core, without locking laminations;

Figure 3 is an end elevation view of another core similar to the one of Figure 2 but with locking laminations;

Figure 4 is an end elevation view on a reduced scale showing a toroid like that of Figure 1, but with cuts for making a different embodiment of the core; and

Figure 5 is an end elevation view of a core made from the toroid of Figure 4, but without the locking laminations.

Figure 6 is an end elevation of a toroid from which a typical one of the loops of a three-phase core is formed.

Figure 7 is an end elevation view on an enlarged scale of the typical core loop;

Figure 8 is an end elevation view of the three phase core of this invention; and

Figure 9 is a fragmentary and elevation view of a leg of a slightly modified form of a core loop;

Figure 10 is an end elevation view of a three phase transformer core and three-phase coil combination, the coil arrangement being shown in section.

Referring now to Figure 2, a core 10 has a main group 11 of concentrically wound laminations 12—22. These laminations have butt joints 12ᴵ—22ᴵ, respectively, in one leg and butt joints 12ᴵᴵ—22ᴵᴵ, respectively, in the other leg. The joints 12ᴵ—22ᴵ are staggered or offset in a constant direction. Likewise, the joints 12ᴵᴵ—22ᴵᴵ are offset in a constant direction, and these offsets in the core legs are substantially parallel to one another, as clearly shown in Figure 2.

The arrangement of these joints 12ᴵ—22ᴵ and 12ᴵᴵ—22ᴵᴵ separates the lamination groups 11 into upper and lower halves 23 and 24. In some transformer applications, such as magnetic amplifiers, core laminations with only one joint are almost impossible to assemble around the coil. For these transformers, the laminations must have two joints so they can be inserted directly into the eye of the coil. Hence the division of the group 11 into the halves 23 and 24.

Because the joints 12ᴵ—22ᴵ and 12ᴵᴵ—22ᴵᴵ are offset as has been explained, the group halves 23 and 24 can be joined together as units. One half, for example, the lower half 24, may be positioned around part of the coil. Then the other half 23 is positioned as a group with its ends abutting the exposed ends of the first half. The easiest way to put the halves together is to slide them slightly laterally as they are brought together. To illustrate, the upper group half 23 may be moved slightly to the right as it is moved downwardly into engagement with the lower half 24. The uniformly staggered joints 12ᴵ—22ᴵ and 12ᴵᴵ—22ᴵᴵ fit together simultaneously and easily.

The joint of Figure 2 is made from concentric laminations 12—22 wound in toroid as shown in Figure 1. The toroid has straight cuts 25 and 26 which form the joints 12ᴵ—22ᴵ and 12ᴵᴵ—22ᴵᴵ when the laminations are shifted and the core is bent to the rectangular shape of Figure 2.

Figure 3 illustrates a core 30 similar to the core of Figure 2 with a group 31 of laminations 32—46. These laminations have staggered butt joints 32ᴵ—46ᴵ in one leg and staggered butt joints 32ᴵᴵ—46ᴵᴵ in the opposite leg, similar to the joints on the core of Figure 2, but staggered by lesser amounts.

The core 30 also has inner and outer locking laminations. There are three inner locking laminations 47, 48 and 49 having staggered butt joints 47ᴵ, 48ᴵ and 49ᴵ located on a leg on the core different from the ones that have the joints 32ᴵ—46ᴵ, and 32ᴵᴵ—46ᴵᴵ. A single outside locking lamination 50 has its butt joint 50ᴵ located on the same leg as the joints 47ᴵ, 48ᴵ and 49ᴵ. These locking laminations 47—50 eliminate the need for special bonding plastics and varnishes that introduce mechanical stresses in the core. Also, because the joints 47ᴵ—50ᴵ are located in a different leg of the core from the joints of the main group 31, they reduce rattling at the joints 32ᴵ—46ᴵ and 32ᴵᴵ—46ᴵᴵ.

Figure 4 illustrates another toroid of concentric wound laminations 55—65, but with cuts 66 and 67 made at an angle to a radius of the toroid. The core 70 of Figure 5 is made from the toroid of Figure 4, and the cuts 66 and 67 produce slanted joints 55ᴵ—65ᴵ and 55ᴵᴵ—65ᴵᴵ as clearly shown in Figure 5. These oblique angled joints reduce the exciting volt amperes.

Further mention should be made of the locking in addition to the laminations 47—50 in Figure 3, if more than one group of main laminations 32—46 is used for a core, the groups may be separated by one or more locking laminations. Also, the number of locking laminations used may be varied with different core applications. Three inner locking laminations 47—49 and one outer locking lamination 50 are shown for illustration.

The joints of the locking laminations are shown to be spaced about 90° around the core from the main joints 12ᴵ—22ᴵ and 12ᴵᴵ—22ᴵᴵ. This is normally the most convenient location and the one most likely to reduce the noise level of operation, but the locking lamination joints may be moved closer to the other joints and may even be located upon the same leg of the core. For example, if the inner locking lamination joints 47ᴵ—49ᴵ are located toward the top of the left leg, as viewed in Figure 3, they would still be far enough from the joints 32ᴵ—

46' to perform their locking function. On the ther hand, if the joint 50' be located on the same left core leg, it is best that the joint be near the lower end.

Referring to Figure 8 of the drawings, the core 10 has three core loops 11, 12 and 13 each comprising a plurality of magnetically oriented metal laminations. The two inner loops 11 and 12 are substantially identical. The outer loop 13 is larger and is wrapped about the two inner loops. The core loop 11 is formed to a rectangle with opposing legs 14 and 15 between the opposing yokes 16 and 17; the loop 12 has legs 18 and 19 and yokes 20 and 21; and the outer loop 13 has legs 22 and 23 and yokes 24 and 25.

The core loop 11 has a group of principal laminations 26 to 36. These laminations 26 to 36 have butt joints 26' to 36' located on the leg 14 and butt joints 26'' to 36'' located on the leg 15. These joints divide the main laminations 26 to 36 into upper and lower halves 37 and 38.

The joints 26' to 36' located on the leg 14 are staggered or offset in a constant or uniform direction along a portion of the leg 14. Similarly, the joints 26'' to 36'' on the leg 15 are staggered. The staggering of the joints 26' to 36' is substantially parallel to the staggering of the joints 26'' to 36''.

Inward of the group of laminations 26 to 36, the core loop 11 has one or more, and preferably three, locking laminations 39. These locking laminations 39 have single butt joints 39' located on a different leg 16 from the legs 14 and 15. The joints 39' are also staggered butt joints.

The other inner core loop 12 has a group of principal laminations 41 to 51. These laminations 41 to 51 have staggered butt joints 41' to 51' located on the leg 18 and staggered butt joints 41'' to 51'' located on the joint 19. The staggering of these joints is also in a constant direction along the legs 18 and 19 as described for the loop 11.

The joints 41' to 51' and 41'' to 51'' divide the laminations 41 to 51 into two halves 52 and 53. The loop 12 has three inner locking laminations 54 having single butt joints 54' located on the leg 20. The joints 54' are staggered.

The larger outside core loop 13 includes a main group of laminations 36 to 65 having butt joints 56' to 65' located on the leg 22 and butt joints 56'' to 65'' located on the leg 23. These joints 56' to 65' and 56'' to 65'' are staggered or offset in a constant direction along their respective legs. The joints divide the laminations 56 to 65 into upper and lower halves 66 and 67. Immediately inward of the laminations 56 to 65, the loop 13 has a single lamination 74 having a butt joint 74' located near the center of the leg 22 and a butt joint 74'' located near the center of the leg 23. Then there are two inner locking laminations 68 each having a single butt joint 68' located on the leg 24 of the loop 13. An outside locking lamination 69 surrounds the loop 13. It has a single spaced joint 69'.

The main laminations 26 to 36 and 41 to 51 of the inner core loops 11 and 12 are made from a toroid like the one shown in Figure 1. This toroid comprises a group of laminations 70 wound concentrically as shown. Straight radial cuts 71 and 72 are made through opposite sides of the toroid. Then, when the laminations 70 are individually shifted and bent to the rectangular shape illustrated in Figure 2, and laminations 26 to 36 with the staggered joints 26' to 36' and 26'' to 36'' are formed. In the same way, the laminations 41 to 51 are formed.

The plurality of laminations 56 to 65 are made from a similar, but larger, toroid than the one shown in Figure 1.

Each loop 11, 12 and 13 has been described as having a main group of laminations with one or more locking laminations on its inner and outer sides. In practice there is often more than one group of main laminations for each loop. In such cases, the joints of each group are staggered as explained. The groups are separated by locking laminations. For example, in Figure 9, a leg of a typical core loop 75 is illustrated as having three main groups of laminations 76, 77 and 78. These groups have staggered joints 76', 77' and 78', respectively, extending in constant directions substantially parallel to one another along the leg of the core. The opposite leg of the loop 75 has identical joints parallel to the joints 76', 77' and 78'. There is a locking lamination 79 on the inner side of the loop having a single joint 79' spaced from the joints 76', 77' and 78'. Locking laminations 80 and 81 are betwen the groups, and these locking laminations also have only one joint 80' and 81' each, which is spaced from the other joint. There is also an outer locking lamination 82 with its spaced joint 82'.

The three phase core of Figure 8 is intended to be used with a coil group of three coils, C_1, C_2 and C_3 arranged in a row in side-by-side relationship, and illustrated in broken lines. Each of the coils C_1, C_2 and C_3 is wound in a loop as is conventional, with the sides of each coil being its legs and the open space at the center being its window.

In assembling the core of Figure 8, the inner locking laminations 39 are first wrapped around the two adjacent legs of the coils C_1 and C_2. These may be wrapped individually or as a group. Next, one of

the halves 37 or 38 of the main group of laminations 26 to 36 is placed against one side of the outermost one of the locking laminations 39, thereby surrounding one-half of these locking laminations. Then the other half 37 or 38 is moved into position with the exposed ends abutting the exposed ends of the first half to form the joints 26^1 to 36^1 and 26^{11} to 36^{11}. Since the joints 26^1 to 36^1 and 26^{11} to 36^{11} are staggered in a constant direction along the legs of the loop 11, and the staggering of the joints on one leg is parallel to the staggering on the other leg, the halves 36 and 37 can be assembled as a group.

The inner core loop 12 is assembled like the loop 11, but around the adjacent legs of the coils C_2 and C_3, beginning with the inner locking laminations 54 and followed by the individual halves 52 and 53 of the plurality of laminations 41—51. The locking laminations 54 like the locking laminations 39, eliminate rattling of the joints and also provide strength to the inner side of the lamination groups. Since the windows of the coils about which the core loops 11 and 12 are wound are unrestricted before the main group of laminations 26—36 and 41—51 are installed, the locking laminations are easily inserted.

The outer core loop 13 is wound onto the inner groups 11 and 12 beginning with the locking laminations 68. After these laminations are in place, the single lamination 74 is placed around them. Then the halves 66 and 67 are positioned around the outer lamination 67. The leg 22 of the loop 13 extends through the window of the coil C_1, and the leg 23 extends through the window of the coil C_3. The legs 14 and 19 of the core loops 11 and 12, respectively, also extend through the windows of the coils C_1 and C_3.

As shown in Figure 10, the transformer core 10 comprises thre individual loops 11, 12 and 13, each of which comprises a plurality of laminations. These laminations may be oriented silicon steel or other oriented metal composition commonly used in the induction field. The core loops 11 and 12 are substantially the same size, and in the assembled core, they are positioned alongside one another. The core loop 13 is larger, and when the core is assembled, the loop 13 surrounds the two inner loops 11 and 12, as shown in the drawing.

The laminations in each core loop 11, 12 and 13 are arranged in two separate groups. The core loop 11 has two lamination groups 14 and 15. The group 14 comprises a plurality of laminations 16, 17, 18, 19 and 20. Likewise, the group 15 is comprised of a plurality of laminations 22—26. These groups of laminations 14 and 15, together with any other number f groups which might be employed to make up the core loop 11, together form a generally rectangular core loop having an upper yoke 28, a lower yoke 29, and legs 30 and 31.

Each of the laminations 16—20 has a single butt joint 16^1—20^1, all located on a common leg 31 of the core loop 11. The joints 16^1—20^1 are staggered or lapped.

Similarly, the laminations 22—26 of the core group 15 have butt joints 22^1—26^1. The joints 22^1—26^1 are positioned on the same leg 31 of the core loop and are also staggered.

The core loop 11 has individual locking laminations on its inner and outer sides and between each of the groups 14 and 15. The inner locking lamination 32 has a single butt joint 32^1, but as shown in the drawing, the joint 32^1 is spaced from the joints 16^1—20^1, and 22^1—26^1. This spacing may be as much as 90° as illustrated, or it may be less, so long as the spacing is sufficiently great to provide a gapless lamination span adjacent the area of overall air gap defined by the joints 16^1—20^1 and 22^1—26^1.

A locking lamination 32 is positioned between the lamination groups 16—20 and 22—26. The lamination 33 has a single butt joint 33^1 also spaced from the joints 16^1—26^1. Surrounding both groups of laminations 14 and 15 there is another locking lamination 34 which has a single butt joint 34^1 spaced from the joints of the two groups of laminations 14 and 15.

The other inner core loop 12 also has two separate groups of laminations 40 and 41. The group 40 comprises a plurality of laminations 42—46, and the group 41 comprises a plurality of laminations 48—52. These lamination groups 40 and 41 define a rectangle having an upper yoke 55, a lower yoke 56, and legs 57 and 58. The leg 57 is adjacent to the leg 31 of the core loop 11.

The laminations 42—46 of the group 40 have butt joints 42^1—46^1 located on the leg 57 of the core loop 12. The joints 42^1—46^1 are staggered. The laminations 48—52 also have single butt joints 48^1—52^1 which are staggered along the leg 57.

The loop 12 has an inner locking lamination 59 which has a single butt joint 59^1 spaced from the joints 48^1—52^1 and 42^1—46^1 by approximately 90°. Another locking lamination 60 separates the two lamination groups 40 and 41. The locking lamination 60 has a single butt joint 60^1 also spaced from the joints 42^1—52^1. Finally, there is an outer locking lamination 61 surrounding the two groups 40 and 41, and having a single butt joint 61^1 spaced like the joints 59^1 and 60^1 of the other locking laminations.

The outer core loop 13 comprises two lamination groups 65 and 66. The lamina-

tion group 65 includes a plurality of laminations 67 to 71 and a group 66 comprises a plurality of laminations 73 to 77. These laminations 67—71 and 73—77 define a rectangular core loop having an upper yoke 79, a lower yoke 80, and legs 81 and 82. The laminations 67 through 71 have joints 67^1 through 71^1 which are located on the upper yoke 79. The joints 67^1 to 71^1 are staggered. The laminations 73 to 77 of the group 66 have staggered butt joints 73^1 to 77^1, also located on the yoke 79 of the outer loop 13.

The loop 13 has an inner locking lamination 84 which has a single butt joint 84^1 spaced 90° from the joints 67^1 to 77^1. A central locking lamination 85 separates the lamination groups 65 and 66. The locking lamination 85 has a single butt joint 85^1 which is also spaced 90° from the joints 67^1 to 77^1. A locking lamination 86 surrounds the outer side of the laminations 67 to 77. This lamination 86 also has a single butt joint 86^1 which is spaced from the main lamination joints 67^1 through 77^1.

The locking laminations which have been described are extremely important in the over-all operation of this transformer core. They perform several functions. Since the joints of the locking laminations are spaced from the joints of the main groups of laminations, they provide a clamping effect on opposite sides of the main lamination groups. Therefore, during operation of the core, the core does not rattle at its joints. Likewise, the locking laminations provide a flux path on the inner and outer sides of the individual lamination groups which confine the flux to its path of travel through the laminations of the groups because the flux has a ready path through the locking laminations when it attempts to bridge the gaps of the main lamination group. Also, the locking laminations add structural strength to the core and hold it tightly together, both during assembly and during operation.

Whereas the locking laminations have been illustrated and described as being located approximately 90° away from the main lamination joints of each core loop, they may be otherwise positioned. What is important is that the joint of each locking lamination be spaced far enough from the lamination joints of each group of laminations to provide the physical locking aforesaid and to provide the outer flux path as explained.

This three-phase transformer core is easy to assemble about a three element three-phase coil combination. For example, a coil combination comprising three individual coils 90, 91 and 92 is illustrated in Figure 10. The coil 90 has legs 93 and 94 on opposite sides of a coil window 95. The coil 91 has legs 96 and 97 on opposite sides of its coil window 98, and the coil 92 has coil legs 99 and 100 on opposite sides of its coil window 101.

Assembling of the core 10 about the pre-assembled coil units 90, 91 and 92 begins with the inner core loops 11 and 12. In assembling the inner core loop 11, the innermost locking lamination 32 is first wrapped around the legs 94 and 96 of the coils 90 and 91 as it is spread apart at its joint 32^1. When the lamination 32 is released, its ends spring together to make the small gap joint 32^1. Next, the entire group 14 of laminations 16—20 is assembled. To do so, the group of laminations 16—20 is grasped and the joints 16^1—20^1 are spread apart. Then the group is positioned around the coil legs 94 and 96 and the ends are released, whereupon they spring together to position the laminations 16—20 as illustrated in the drawing.

When the group 14 is in position, the dividing or separating locking lamination 33 is wrapped about the group 14. Then the group 15 is assembled about the locking lamination 33, and finally the outer locking lamination 34 is wrapped about the group 15.

It should be here noted that when the dividing or separating locking lamination 33 is in position, it pulls the joints 16^1—20^1 together thereby producing a tight fit between the individual joints 16^1—20^1. Since the locking lamination 33 holds these laminations 16 through 20 in position, when the next lamination group 15 is wrapped about the locking lamination 33, the individual laminations 22 through 26 accurately spring into place. Then, when the outer locking lamination 34 is positioned about the group 15, it holds the laminations 22 through 26 tightly in position.

The inner core loop 12 is assembled in much the same way as the loop 11. The locking laminations 59, 60 and 61 hold the lamination groups 40 and 41 tightly and accurately in position.

When the two inner core loops 11 and 12 are in position, the outer loop 13 is wrapped about them. This begins with the inner locking lamination 84 which is wound about the outer side of both the inner core loops 11 and 12. Next the group 65 of laminations is wound as a group about the inner locking lamination 84. When the separating locking lamination 85 is wrapped about the group 65, it holds the laminations 67 to 71 tightly and compactly pressed inwardly against the inner locking lamination 84.

The positioning of the separating locking lamination 81 is followed by the group 66 and finally by the outer locking lamination 86.

WHAT WE CLAIM IS:—

1. A transformer core including a plurality

of metal laminations each forming a substantially rectangular closed loop and each having a butt joint in at least one side of the loop, the butt joints of adjacent laminations being arranged in staggered relation along at least part of the length of each of two different limbs of the core formed by sides of adjacent laminations, and at least one innermost and/or outermost lamination having a butt joint in a side of its loop remote from the butt joints in the laminations adjacent thereto.

2. A transformer core including a plurality of metal laminations each forming a substantially rectangular closed loop and each having two butt joints one in each of two opposite sides of the loop, the butt joints in adjacent laminations being arranged in staggered relation along at least a part of the length of each of two opposite sides of the core and at least one innermost and/or outermost lamination having a butt joint in a side of its loop remote from the butt joints in the laminations adjacent thereto.

3. A three phase transformer core comprising three groups of metal laminations each lamination forming a substantially rectangular closed loop and each having a butt joint in at least one side of the loop, the butt joints of adjacent laminations in each group being arranged in staggered relation along at least part of the length of one side of the rectangular loop formed by such group, and the groups being so arranged that the staggered butt joints of at least two of said groups lie in different limbs of the core, and at least one innermost and/or outermost lamination having a butt joint in a side of its loop remote from the butt joints in adjacent laminations.

4. A three phase transformer core comprising three groups of metal laminations each lamination forming a closed loop and having two butt joints one in each of two opposite sides of the loop, the butt joints in each said group being arranged in staggered relation along at least part of the length of each of said two opposite sides of the loop of that group and at least one innermost and/or outermost lamination having a butt joint in a side of its loop remote from the butt joints of adjacent laminations.

5. A transformer core as claimed in any one of claims 1 to 4 in which the staggered butt joints of a group of adjacent laminations are staggered in a single direction along the length of the side of the loop formed by such group.

6. A transformer core as claimed in any one of claims 1 to 5 in which the innermost and/or outermost lamination, is a locking lamination serving to clamp or assist in clamping the other laminations.

7. A core as claimed in claim 3 r 4 or in claim 5 or 6 as appendant to claim 3 or 4 wherein one of the groups is larger than the other two, the latter being positioned side-by-side within the central aperture of the former.

8. A core as claimed in claim 7 wherein each group of laminations comprises at least two sub-groups each having inner and outer locking laminations.

9. A transformer core as claimed in claim 2 wherein there are at least five and not more than twenty laminations.

10. A transformer core as claimed in claim 2 or 9 wherein the staggering of the joints along one side of the core is in substantially parallel relation to the staggering of the joints along the opposite side.

11. A transformer core as claimed in any one of claims 2, 9 and 10 including inner and outer locking laminations, each having a single butt joint.

12. A transformer core as claimed in any one of the preceding claims wherein the jointing lines of the individual butt joints are slanted with respect to the planes of the laminations.

13. A transformer core as claimed in any one of the preceding claims in which the laminations are of magnetically oriented strip metal.

14. A three phase transformer comprising a three phase core as claimed in any one of claims 7, 8, 12 and 13 and three coils, two of said coils each encircling one of two opposite sides of the loop of said one group and an adjacent side of the loop of one of the other two groups and the third coil encircling adjacent sides of said other two groups.

15. A transformer core substantially as herein described with reference to Figures 1 to 5 of the accompanying drawings.

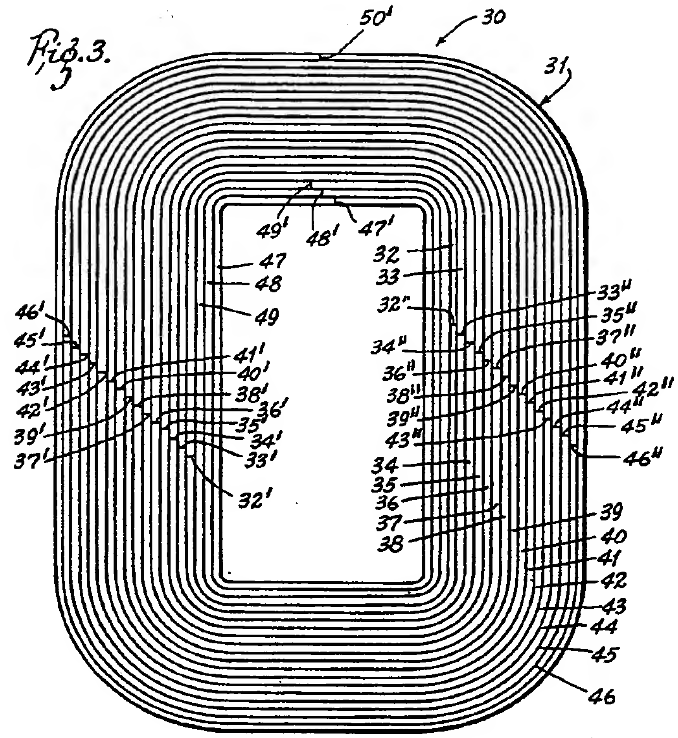
16. A transformer core substantially as herein described with reference to Figures 6 to 9 of the accompanying drawings.

17. A transformer core substantially as herein described with reference to Figure 10 of the accompanying drawings.

A. A. THORNTON & CO.,
Chartered Patent Agents,
Northumberland House,
303—306 High Holborn,
London, W.C.1,
For the Applicants.

Leamington Spa: Printed for Her Majesty's Stationery Office by the Courier Press.—1964.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

Fig. 3.



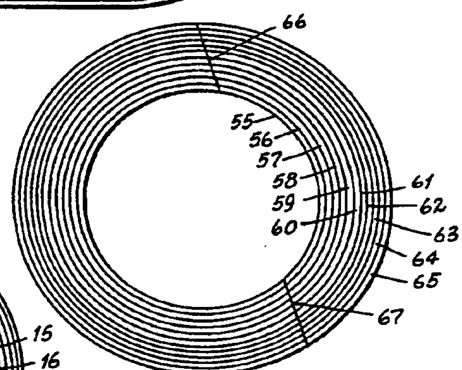
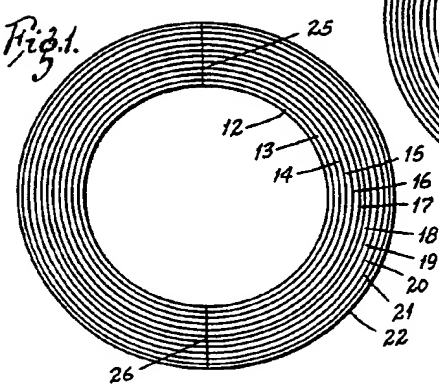


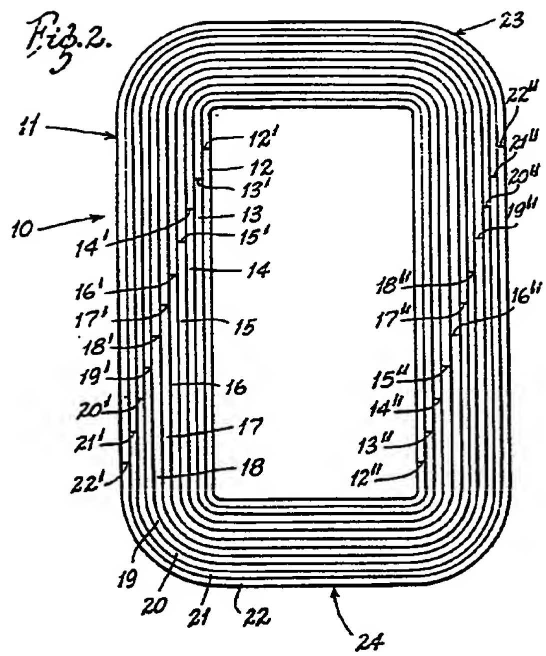
Fig. 4.

Fig. 1.



965,741 COMPLETE SPECIFICATION
4 SHEETS *This drawing is a reproduction of the Original on a reduced scale.*
SHEETS 1 & 2

Fig.2.



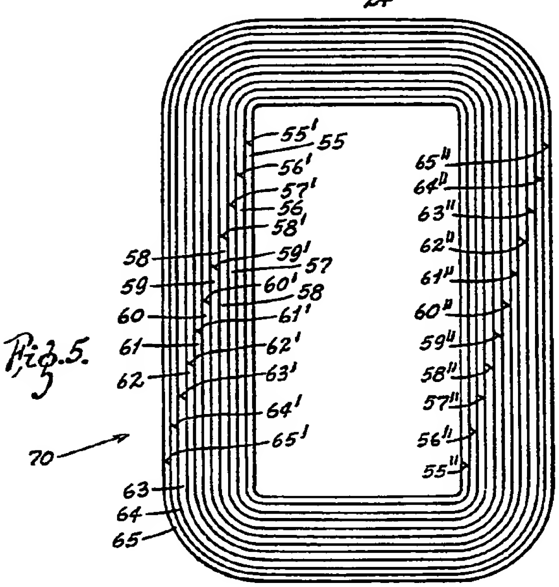


Fig.5.

965,741 COMPLETE SPECIFICATION
4 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2

Fig.3.

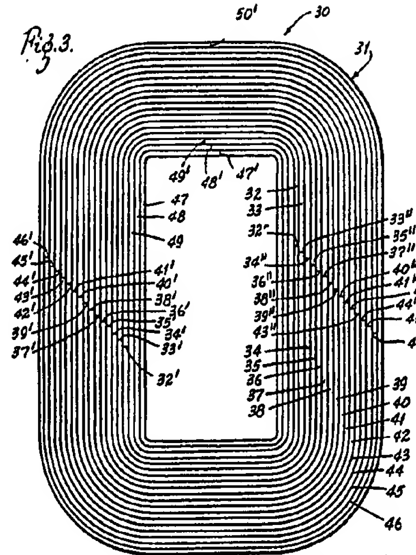


Fig.2.

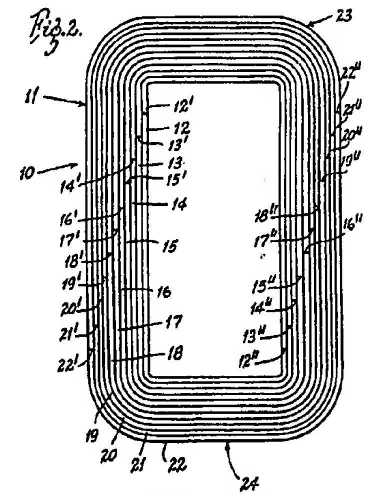


Fig.1.

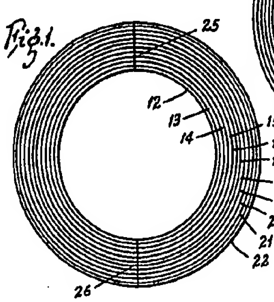


Fig.4.

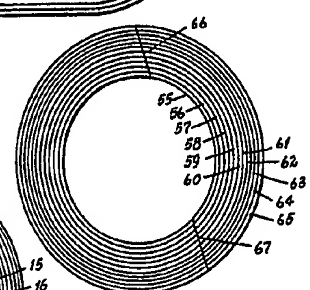


Fig.5.

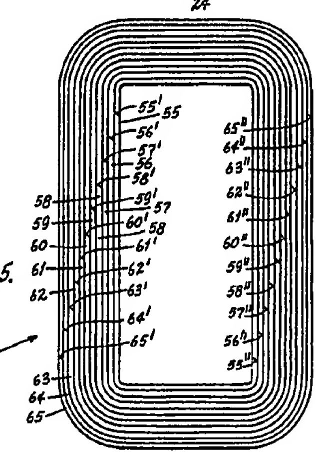
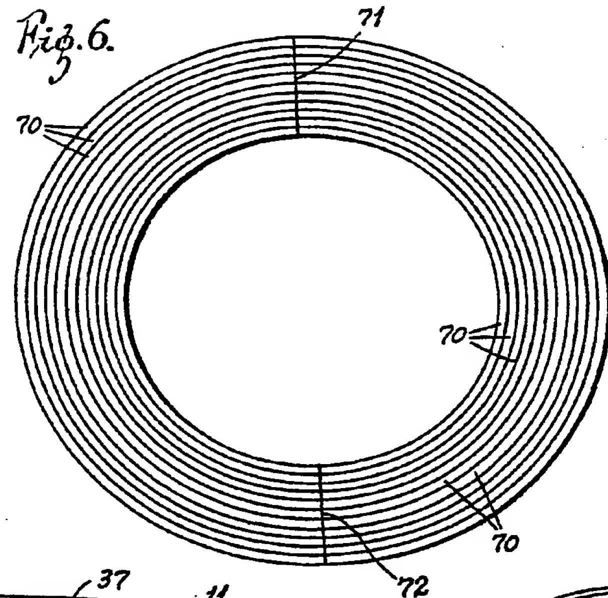
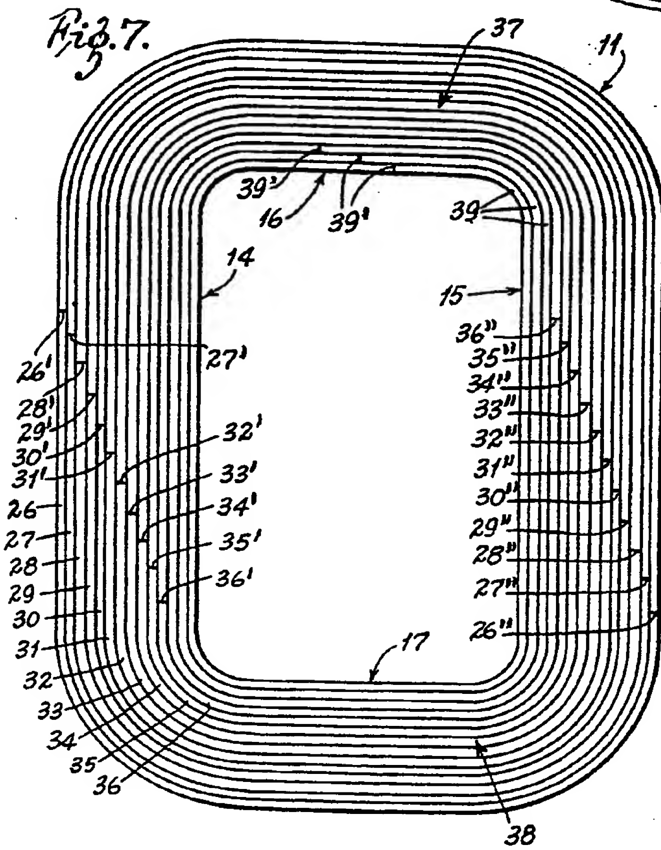


Fig. 6.

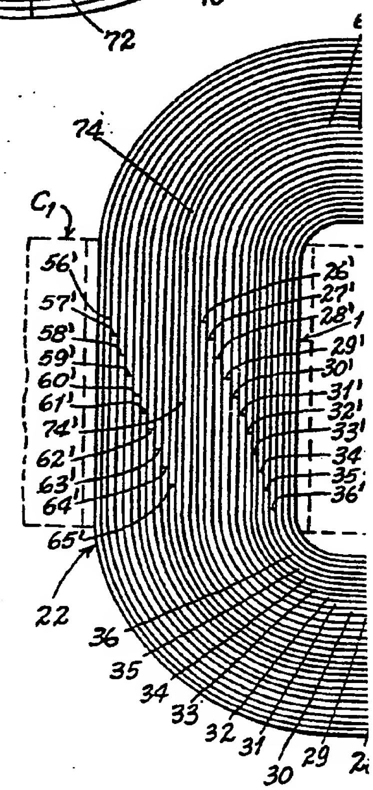


71
70
70
70
72

Fig. 7.

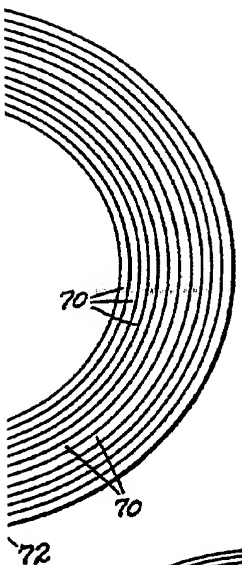


37
11
39'
16
39'
39
14
15
27'
26'
28'
29'
30'
31'
26
27
28
29
30
31
32
33
34
35
36
32'
33'
34'
35'
36'
36''
35''
34''
33''
32''
31''
30''
29''
28''
27''
26''
17
38



74
C1
56'
57'
58'
59'
60'
61'
74'
62'
63'
64'
65'
22
36
35
34
33
32
31
30
29
26'
27'
28'
29'
30'
31'
32'
33'
34
35'
36'

965,741 COMPLETE SPECIFICATION
4 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEET 3



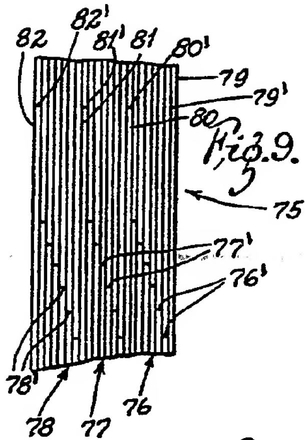
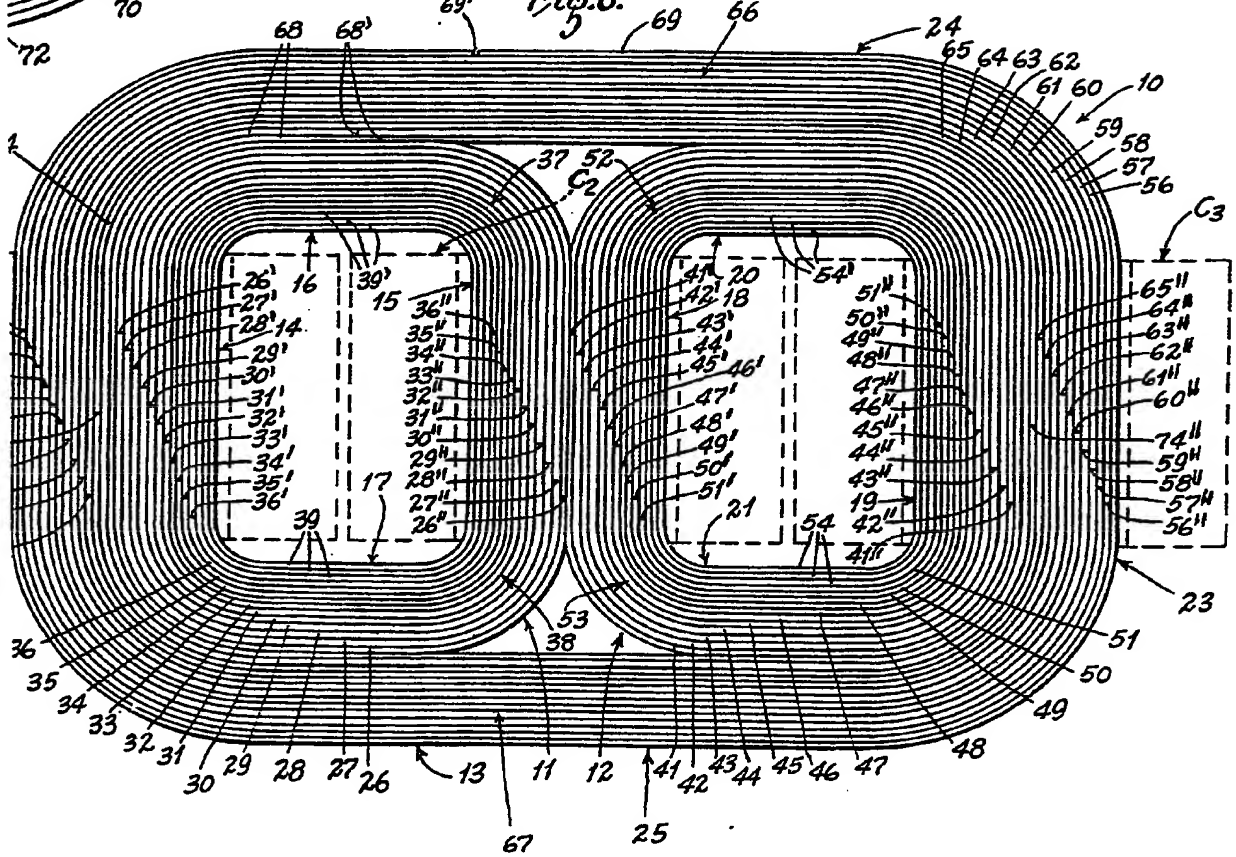


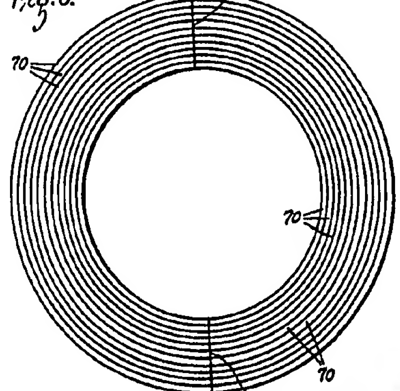
Fig.9.

Fig.8.



965,741 COMPLETE SPECIFICATION
4 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEET 3

Fig.6.



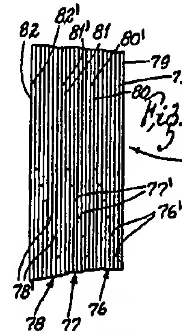


Fig.9.

Fig.7.

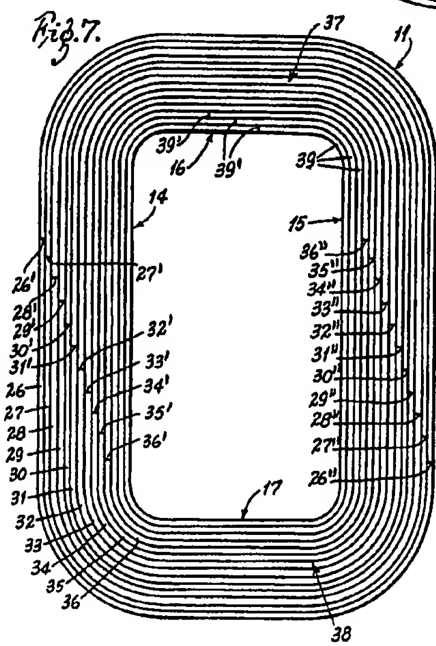
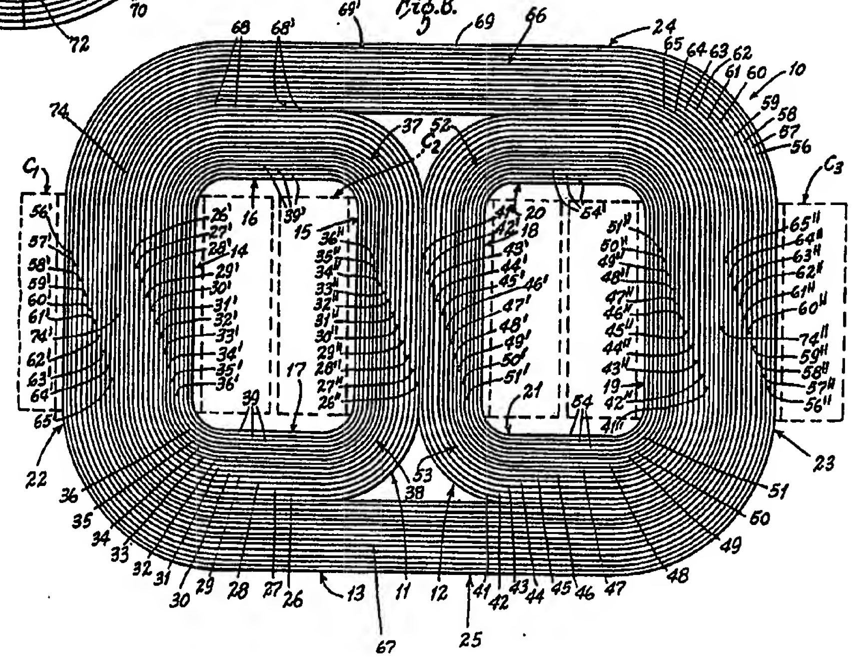


Fig.8.



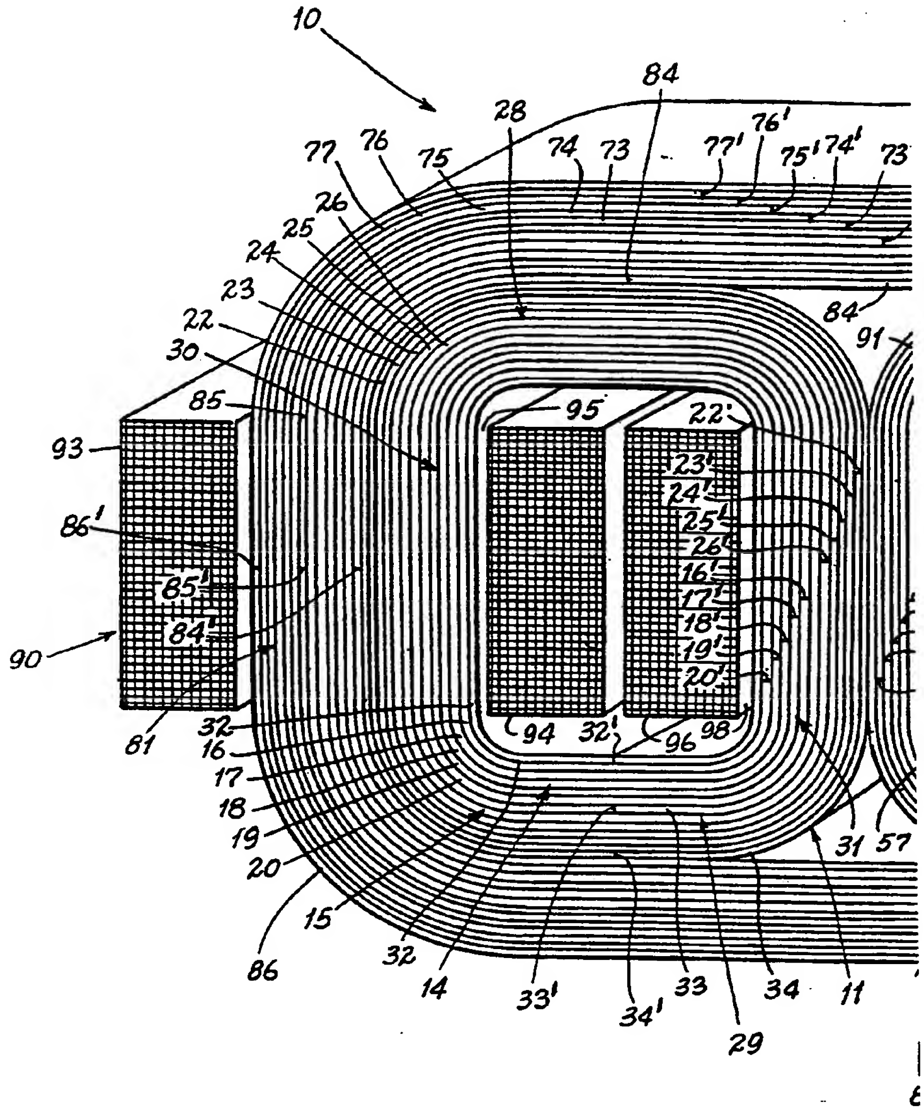
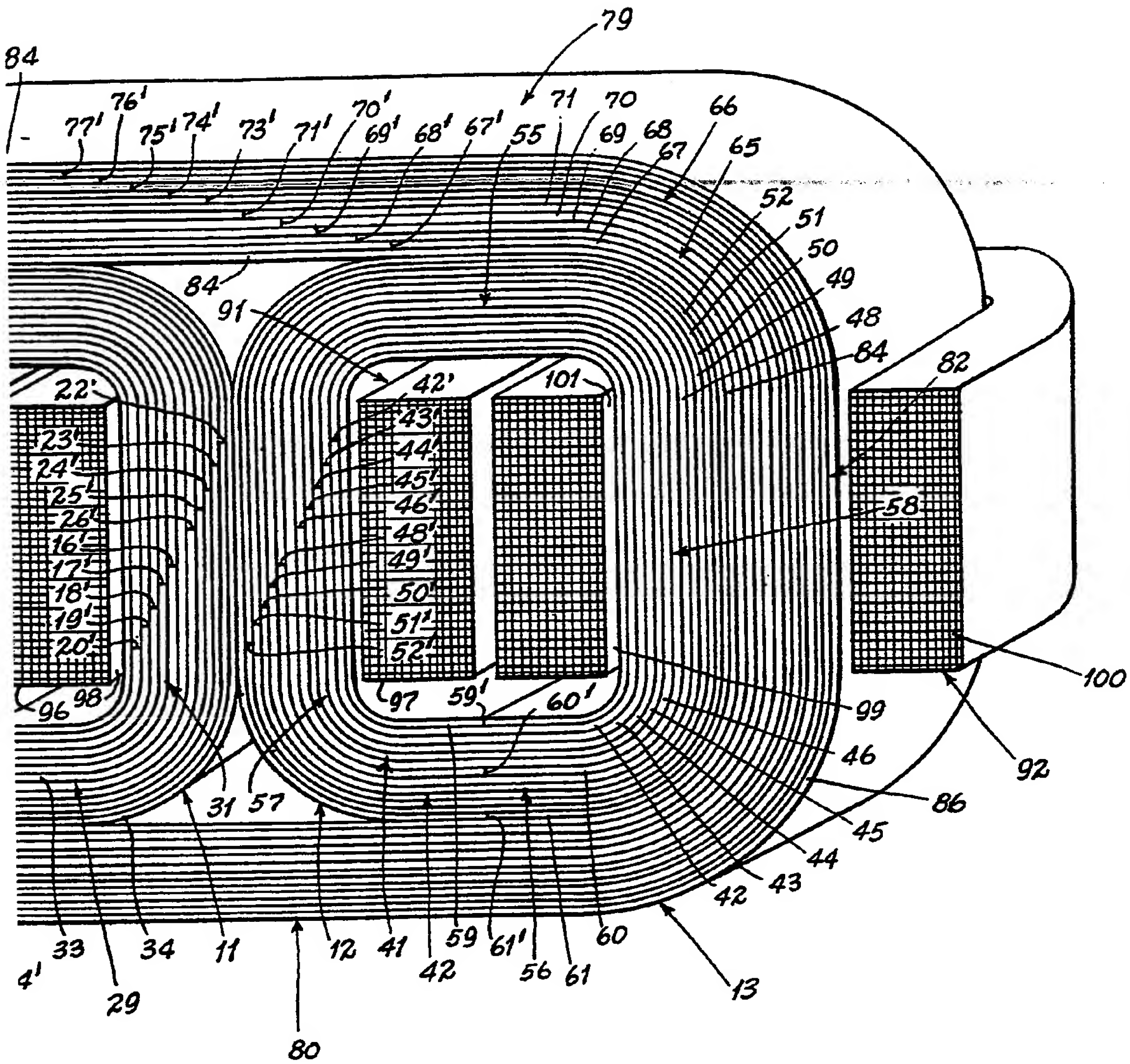

10
84
28
77
76
75
74
73
77'
76'
75'
74'
73
26
25
24
23
22
30
85
93
95
22'
23'
24'
25'
26'
16'
17'
18'
19'
20'
84
91
86'
85'
84'
90
81
32
16
17
18
19
20
15
86
32
14
33'
34'
33
29
34
11
31
57
94
32'
96
98

Fig.10.

965,741 COMPLETE SPECIFICATION
4 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEET 4



ig.10.

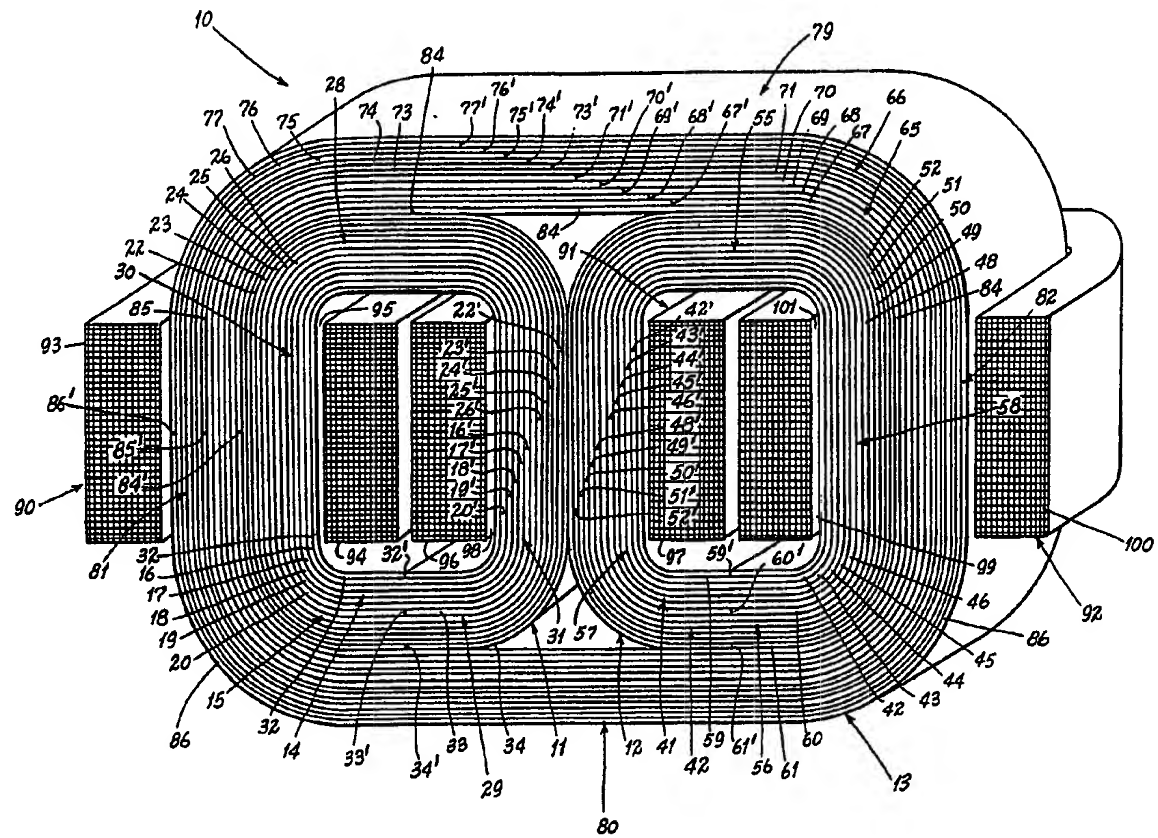


Fig.10.